National Aeronautics and Space Administration

SPACE SHUTTLE MISSION STS-90

PRESS KIT APRIL 1998

NEUROLAB

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LIFE SCIENCES RESEARCH HIGHLIGHTS STS-90 NEUROLAB MISSION

An upcoming two week plus stay in Earth orbit will give seven NASA astronauts aboard Space Shuttle Columbia the opportunity to focus on the most complex and least understood part of the human body, the nervous system, during the STS-90 Neurolab mission.

The STS-90 crew will be commanded by Richard A. Searfoss, who will be making his third Shuttle flight. The pilot, Scott D. Altman, will be making his first flight. There are three mission specialists assigned to this flight. Richard M. Linnehan, serving as the Payload Commander and Mission Specialist-1, is making his second flight. Mission Specialist-2 Kathryn P. (Kay) Hire is making her first flight. Dafydd (Dave) Rhys Williams from the Canadian Space Agency will serve as Mission Specialist-3 and is making his first flight. Two payload specialist round out the STS-90 crew. Jay Clark Buckey, Jr. will serve as Payload Specialist-1 and James A. (Jim) Pawelczyk will be Payload Specialist-2. Both Buckey and Pawelczyk are making their first space flight.

Columbia is targeted for launch on April 16, 1998 from NASA's Kennedy Space Center Launch Complex 39-B. The 2 _ hour available launch window opens at 2:19 p.m. Eastern. The STS-90 mission is scheduled to last 15 days, 21 hours, 50 minutes. However, mission managers are reserving an option of extending the flight one additional day for science operations if Shuttle electrical power margins permit. A launch on April 16 and a 16 or 17 day nominal mission being flown would have Columbia landing back at Kennedy Space Center on May 2 or May 3.

During the mission, the crew will perform their studies in the Spacelab module being carried in Columbia's payload bay. The Spacelab will provide the astronauts a working research laboratory with living conditions similar to those on Earth, but with one key difference: microgravity.

The prime mission objective for the STS-90 Neurolab mission is to conduct research that will contribute to a better understanding of the human nervous system. Made up of the brain, spinal cord, nerves, and sensory organs, this system faces major challenges in microgravity. The nervous system controls blood pressure, maintains balance, coordinates movements, and regulates sleep -- areas that are all affected by space flight.

Since this flight focuses on basic research questions in neuroscience, the mission will provide a unique contribution to the study and treatment of neurological diseases and disorders. While the foremost goal of Neurolab is to expand our understanding of how the nervous system develops and functions in space, the research will also increase our knowledge of how this system develops and functions on Earth.

International agencies, including the Canadian Space Agency, French Space Agency, German Space Agency, European Space Agency and Japanese Space Agency, are partners with NASA for the Neurolab mission. They have provided flight and ground hardware for various research experiments and will support investigations from their respective countries.

On the flight, the crew will serve as both experiment subjects and operators. STS-90 crewmembers will work with a wide array of biomedical instrumentation, including some instruments and devices developed especially for the mission. The crew will not be the only living things on board; Neurolab will also carry rats, mice, two kinds of fish, snails, and crickets into space.

Neurolab has a significant place in NASA's long-range plans. Long-duration space flights will become common as the International Space Station is built and occupied. This makes an understanding of how the human body functions in microgravity essential. Neurolab is expected to contribute key answers, clarifying the requirements for our future residency on the International Space Station and for aiding research on Earth.

Also flying in Columbia's payload bay will be several small canisters called Hitchhiker and Get Away Special (GAS) payloads.

The Hitchhiker payload involves the Shuttle Vibration Forces (SVF) experiment which will make the first of two flights on STS-90 and will measure the dynamic forces acting between the Space Shuttle and a canister attached to the Shuttle sidewall. The SVF experiment will provide measurements of the dynamic forces acting on Shuttle equipment and will enable NASA to fly more sophisticated equipment on the Shuttle, at less cost.

The three GAS payloads on STS-90 have a variety of objectives. One involves an experiment featuring the world's smallest version of a new type of refrigerator. Known as the pulse tube refrigerator, this experiment will demonstrate the pulse tube cooling technology in the zero gravity environment of space. Pulse Tube refrigerators, or cryocoolers, can be used to cool infrared sensors and other devices used in space based research studies of the temperature variations in the atmosphere and oceans, the understanding of the ozone hole, global warming and long range weather forecasting.

The second GAS payload, developed by students at the University of Colorado, Boulder will analyze the gentle collisions of dust particles in space which may shed new light on the sources of dust in planetary rings. The evolution of planetary rings is controlled by collisions between ring particles. These collisions are slow and gentle. Some dust is released when larger particles collide, resulting in dust rings and in the loss of orbital energy of the larger particles. The gravity of the large particles is small, so the phenomenon of dust release in gentle collisions between these particles requires a microgravity environment. Although dust is present in the rings of the four gaseous giant planets, how dust is knocked off larger ring particles a meter or more across during their continuous collisions with each other remains a mystery.

The final GAS payload is from Sierra College in Rocklin, CA and the objective of this experiment is to take ozone measurements of the Earth's upper atmosphere in the ultraviolet 200 nanometer to 400 nanometer spectral range using a Charge Coupled Device based spectrometer. The spectrometer will autonomously begin taking data when the Earth is in the instrument field of view as detected by ultraviolet intensity.

STS-90 will be the 25th flight of Columbia and the 90th mission flown since the start of the Space Shuttle program in April 1981.

MEDIA SERVICES INFORMATION

NASA Television Transmission

NASA Television is available through the GE2 satellite system which is located on Transponder 9C, at 85 degrees west longitude, frequency 3880.0 MHz, audio 6.8 MHz.

The schedule for television transmissions from the orbiter and for mission briefings will be available during the mission at Kennedy Space Center, FL; Marshall Space Flight Center, Huntsville, AL; Dryden Flight Research Center, Edwards, CA; Johnson Space Center, Houston, TX; and NASA Headquarters, Washington, DC. The television schedule will be updated to reflect changes dictated by mission operations.

Status Reports

Status reports on countdown and mission progress, on-orbit activities and landing operations will be produced by the appropriate NASA newscenter.

Briefings

A mission press briefing schedule will be issued before launch. During the mission, status briefings by a flight director or mission operations representative and when appropriate, representatives from the payload team, will occur at least once each day. The updated NASA television schedule will indicate when mission briefings are planned.

Internet Information

Information on STS-90 is available through several sources on the Internet. The primary source for mission information is the NASA Shuttle Web, part of the World Wide Web. This site contains information on the crew and its mission and will be regularly updated with status reports, photos and video clips throughout the flight. The NASA Shuttle Web's address is:

http://shuttle.nasa.gov

If that address is busy or unavailable, Shuttle information is available through the Office of Space Flight Home Page:

http://www.osf.hq.nasa.gov/

Detailed information on the science operations and objectives associated with the STS-90 mission can be found at the Neurolab Home Page:

http://neurolab.jsc.nasa.gov

General information on NASA and its programs is available through the NASA Home Page and the NASA Public Affairs Home Page:

http://www.nasa.gov
or
http://www.nasa.gov/newsinfo/index.html

Information on other current NASA activities is available through the Today@NASA page:

http://www.nasa.gov/today.html

The NASA TV schedule is available from the NTV Home Page:

http://www.nasa.gov/ntv

Status reports, TV schedules and other information also are available from the NASA Headquarters FTP (File Transfer Protocol) server, ftp.hq.nasa.gov. Log in as anonymous and go to the directory /pub/pao. Users should log on with the user name "anonymous" (no quotes), then enter their E-mail address as the password. Within the /pub/pao directory there will be a "readme.txt" file explaining the directory structure:

* Pre-launch status reports (KSC): **ftp.hq.nasa.gov/pub/pao/statrpt/ksc**
* Mission status reports(JSC): **ftp.hq.nasa.gov/pub/pao/statrpt/jsc**
* Daily TV schedules: **ftp.hq.nasa.gov/pub/pao/statrpt/jsc/tvsked.**

NASA Spacelink, a resource for educators, also provides mission information via the Internet. Spacelink may be accessed at the following address:

http://spacelink.nasa.gov

Access by CompuServe

Users with CompuServe accounts can access NASA press releases by typing "GO NASA" (no quotes) and making a selection from the categories offered.

STS-90 QUICK LOOK

Launch Date/Site:	April 16, 1998/KSC Launch Pad 39-B
Launch Time:	2:19 P.M. EDT
Launch Window:	2 hours, 30 minutes
Orbiter:	Columbia, (OV-102), 25th flight
Orbit Altitude/Inclination:	150 nautical miles / 39 degrees
Mission Duration:	15 days, 21 hours, 50 minutes
Landing Date:	May 2, 1998
Landing Time:	12:09 P.M. EDT
Primary Landing Site:	Kennedy Space Center, Florida
Abort Landing Sites:	Return to Launch Site - KSC Transoceanic Abort Sites - Ben Guerir, Morocco Zaragoza, Spain Moron, Spain Abort-Once Around - Edwards Air Force Base, CA
Crew:	Rick Searfoss, Commander (CDR), 3rd flight Scott Altman, Pilot (PLT), 1st flight Rick Linnehan, Payload Commander, 2nd flight Kay Hire, Mission Specialist 2 (MS 2), 1st flight Daffyd (Dave) Williams, Mission Spec. 3 (MS 3), 1st flight Jay Buckey, Payload Specialist 1 (PS 1), 1st flight James Pawelczyk, Payload Specialist 2 (PS 2), 1st flight
EVA Crewmembers: (if required)	Rick Linnehan (EV 1), Dave Williams (EV 2)
Cargo Bay Payloads:	Neurolab Getaway Special Canisters
In-Cabin Payloads:	Bioreactor Demonstration Test-04 Shuttle Vibration Forces

CREW RESPONSIBILITIES

Payloads	Prime	Backup
Spacelab Systems	Linnehan	Others
Spacelab Science	Linnehan	Others
EVA	Linnehan (EV 1)	Williams (EV 2)
Intravehicular Crewmember	Hire	------
Earth Observations	Altman	Searfoss
Ascent Seat on Flight Deck	Williams	------
Entry Seat on Flight Deck	Linnehan	------

STS-90 ORBITAL EVENTS SUMMARY

(based on an April 16, 1998 Launch)

EVENT	MET	TIME OF DAY (EDT)
Launch	0/00:00	2:19 PM, April 16
Spacelab Activation	0/01:45	4:04 PM, April 16
Crew News Conference	9/19:50	10:09 AM, April 26
Spacelab Deactivation	14/23:40	1:59 PM, May 1
KSC Landing	15/21:50	12:09 PM, May 2

DEVELOPMENTAL TEST OBJECTIVES
DETAILED SUPPLEMENTARY OBJECTIVES
RISK MITIGATION EXPERIMENTS

DTO 623:	Cabin Air Monitoring
DTO 667:	Portable In-flight Landing Operations Trainer (PILOT)
DTO 700-16:	S-Band Sequential Still Video (SSV) Demonstration
DSO 331:	LES and Sustained Weightlessness on Egress Locomotion
DSO 497:	Effects of Microgravity on Cell Meidated Immunity and Reaction of Latent Viral Infections
DSO 904:	Assessment of Human Factors

PAYLOAD AND VEHICLE WEIGHTS

Vehicle/Payload	**Pounds**
Orbiter (Columbia) empty and 3 SSME's	187,646
Shuttle System at SRB Ignition	4,523,513
Orbiter Weight at Landing with Cargo	232,500
Spacelab Module	23,783

MISSION SUMMARY TIMELINE

Flight Day One:
Launch/Ascent
OMS-2 Burn
Payload Bay Door Opening
Spacelab Activation
Neurolab Science

Flight Day 2-15:
Neurolab Science
(Off Duty Periods on Flight Days 5 and 10; Crew News Conference on Flight Day 11)

Flight Day 16:
Flight Control System Checkout
Reaction Control System Hot-Fire
Cabin Stowage
Spacelab Deactivation

Flight Day 17:
Payload Bay Door Closing
Deorbit Burn
KSC Landing

SHUTTLE ABORT MODES

Space Shuttle launch abort philosophy aims toward safe and intact recovery of the flight crew, Orbiter and its payload. Abort modes for STS-90 include:

* Abort-To-Orbit (ATO) -- Partial loss of main engine thrust late enough to permit reaching a minimal 105-nautical mile orbit with the orbital maneuvering system engines.

* Abort-Once-Around (AOA) -- Earlier main engine shutdown with the capability to allow one orbit of the Earth before landing at Kennedy Space Center, Fla.

* Transoceanic Abort Landing (TAL) -- Loss of one or more main engines midway through powered flight would force a landing at either Zaragoza or Moron in Spain or Ben Guerir in Morocco.

* Return-To-Launch-Site (RTLS) -- Early shutdown of one or more engines, and without enough energy to reach a TAL site, would result in a pitch around and thrust back toward Kennedy until within gliding distance.

NEUROLAB MISSION

Neurolab Overview

Neurolab, a NASA research mission dedicated to the study of life sciences, focuses on the most complex and least understood part of the human body, the nervous system. Made up of the brain, spinal cord, nerves, and sensory organs, this system faces major challenges in space. The nervous system controls blood pressure, maintains balance, coordinates movements, and regulates sleep-areas that are all affected by space flight.

During the 16-day mission aboard the Space Shuttle Columbia, the 7-member crew will perform their studies in the Spacelab module. The Spacelab, an internationally developed science module developed by the European Space Agency (ESA), is connected to the middeck of the Space Shuttle by a tunnel and provides a laboratory with living conditions similar to those on Earth, but with one key difference: microgravity.

On the flight, the Neurolab crew will serve as both experiment subjects and operators. Crewmembers will work with a wide array of biomedical instrumentation, including some instruments and devices developed especially for the mission. The crew will not be the only living things on board; Neurolab will also carry rats, mice, fish, snails, and crickets into space.

The experiments have been grouped into eight teams. Four teams (with a combined total of 11 experiments) will use crewmembers as subjects, and 4 teams (with 15 experiments) will study research animals. The teams studying human subjects are the Autonomic Nervous System, Sensory Motor and Performance, Vestibular, and Sleep teams. Teams with animal subjects are the Neuronal Plasticity, Mammalian Development, Aquatic, and Neurobiology teams.

Since Neurolab focuses on basic research questions in neuroscience, the mission will provide a unique contribution to the study and treatment of neurological diseases and disorders. While the foremost goal of Neurolab is to expand our understanding of how the nervous system develops and functions in space, the research will also increase our knowledge of how this system develops and functions on Earth.

At the beginning of this decade, the U.S. Congress and the President designated the 1990's as the "Decade of the Brain" to recognize advances in our understanding of the basic structure and function of the brain. NIH, the National Institute of Health, partnered with NASA in the early development of the concept and selection of mission investigations. The NIH Institute Partners, together with the National Science Foundation and the Office of Naval Research, support the scientific experiments as having important implications for health and quality of life for people on Earth.

International agencies, including the Canadian Space Agency, French Space Agency, German Space Agency, European Space Agency and Japanese Space Agency, have also partnered with NASA from the beginning. They provide flight and ground hardware for Nuerolab experiments and support investigations from their respective countries.

Over 37 years of human spaceflight data collected on how astronauts adapt to microgravity have given researchers the basics of space physiology. Each piece added to the space life sciences puzzle, however, presents more questions to be answered. For example, although all our basic movements (walking, balancing, etc.) were learned with gravity present, how can we adapt so quickly to function without gravity? How do gravity-sensitive parts of the body like the inner ear, cardiovascular system, and muscles learn to cope without gravity? Why are sleep and biological rhythms changed in space? Will inner ears that developed in space function the same as those that developed on Earth? Must gravity be present at the point in life when basic skills like walking are usually learned? These questions will be answered by taking measurements on the crew and on the research animals before, during, and after the flight.

Neurolab has a significant place in NASA's long-range plans. Long-duration space flights will become common as the International Space Station is built and occupied. This makes an understanding of how the human body functions in microgravity essential. Neurolab is expected to contribute key answers, clarifying the requirements for our future residency on the International Space Station and for aiding research on Earth.

STS-90 - NEUROLAB
Autonomic Nervous System Team

An elderly man stands up quickly after awakening, feels dizzy, and falls. A fighter pilot forces his plane into a tight turn and nearly passes out. What links these two causes? In both situations the cardiovascular system (the heart and blood vessels) is stressed by gravity. Since the head is above the heart when we stand or sit, the cardiovascular system must work against gravity to maintain blood flow to the brain. A person whose cardiovascular system is having trouble providing blood flow to the brain when standing is said to have orthostatic intolerance.

Why is orthostatic intolerance a concern for Neurolab? Once back on Earth, astronauts also experience orthostatic intolerance. Results from experiments carried out on previous life sciences Spacelab missions show that while all crew-members could easily stand quietly for 10 minutes before flight, after flight 60 percent needed to sit down before the 10 minutes were up. Some showed significant decreases in blood pressure, while others needed to sit despite an apparently normal, though low, blood pressure. The Autonomic Nervous System Team on Neurolab wants to uncover what changes in the control of blood pressure during space flight lead to the problems astronauts encounter after flight.

Artificial Neural Networks and Cardiovascular Regulation

Experiment No. 081 Subject: Humans
Principal Investigator: Friedhelm J. Baisch, M.D., DLR Institute of Aerospace Medicine, Germany

Integration of Neural Cardiovascular Control in Space

Experiment No.294 Subject: Humans
Principal Investigator: C. Gunnar Blomqvist, M.D., Ph.D., Univ. of Texas Southwestern Medical Center, Dallas, TX, USA

Autonomic Neuroplasticity in Weightlessness

Experiment No. 049 Subject: Humans
Principal Investigator: Dwain L. Eckberg, M.D., Virginia Commonwealth University, Richmond, VA, USA

Autonomic Neurophysiology in Microgravity

Experiment No. 095 Subject: Humans
Principal Investigator: David Robertson, M.D., Vanderbilt University, Nashville, TN, USA

The Autonomic Nervous System team will investigate the nervous system's control of cardiovascular function in the human body in microgravity. On Neurolab, crewmembers will carry out a set of tests to learn how the cardiovascular system changes during spaceflight. In addition to blood pressure, blood flow to the brain will be estimated. High frequency sound waves are used to show how blood flow to the brain is regulated. This is important because not all people who have orthostatic intolerance after space flight experience a drop in blood pressure. They may have a problem with the control of brain blood flow.

Another innovative technique is called microneurography. A small needle (the size of an acupuncture needle) is placed in a nerve just below the knee. The nerve signals traveling from the brain to the blood vessels can then be measured directly, letting us know how the autonomic nervous system is functioning.

The measurements are made while the autonomic nervous system is challenged by a variety of tests. The controlled frequency breathing test allows for the natural fluctuations in the control of blood pressure to be measured precisely. The Valsalva maneuver test stimulates the pressure receptors in the neck and chest and measures the responses. The Lower Body Negative Pressure test places a stress on the cardiovascular system, very similar to the stress experienced when standing in Earth's gravity. The cold pressor and hand grip tests activate the blood pressure control system and raise blood pressure by different methods. The cuff occlusion tests and body impedance measurements show fluid distribution in the body and how this contributes to problems in blood pressure control. The part of the autonomic system that may be functioning improperly can be located, once test results are evaluated.

Earth Benefits - On Neurolab, the control of blood pressure is a major focus of the mission. It is estimated that over one-half million Americans suffer from disorders of autonomic blood pressure control. Data from Neurolab studies can provide insight into orthostatic intolerance syndromes, similar to those observed in astronauts after space flight. Therapy developed from the results of these studies could improve treatment of affected patients here on Earth.

STS-90 - NEUROLAB
Sensory Motor Performance Team

On Earth, when humans make simple, everyday movements like pointing or catching a ball, the nervous system takes gravity into account. The brain processes information from the eyes and inner ear, as well as from nerves in the joints and muscles, to make smooth, accurate movements. In space, the inner ear no longer provides the brain with useful information about "up" or "down." The nerves in the joints are sensing the movements of weightless limbs. The nervous system must adapt so astronauts can function effectively.

The Sensory Motor and Performance Team want to measure this adaptation and understand how it takes place. How does a simple task like catching a ball change without the influence of gravity? Will the muscles tense and prepare for a falling ball prematurely, based on experience in Earth's gravity? Or will the system accommodate the change rapidly? Will vision become more important in determining body position since cues from the inner ear are no longer present? Previous space flights have shown that crewmembers can experience visual illusions in space-particularly when determining what is "up" and what is "down." Is "down" always where the brain determines the "floor" to be? Without gravity as a guide, the brain can interpret a floor as a ceiling or vice versa.

Frames of Reference and Internal Models

Experiment No. 111	Subject: Humans
Principal Investigator:	Alain Berthoz, Ph.D., LPPA CNRS/College de France, Paris, France

A simple, but effective, ball catching experiment tests the ability of the Central Nervous System (CNS) to accept and interpret new stimuli in space. The experiment uses the Kinelite system, an apparatus developed by the Centre National d'Etudes Spatiales (French Space Agency-CNES).A seated astronaut will catch a ball released from a spring-loaded device that propels the ball from overhead "downward" to the astronaut. The ball travels with a constant velocity compared to the constant acceleration that would occur on Earth. As the astronaut reaches out to catch the ball, the system captures three-dimensional images of the moving hand and arm, and simultaneously measures the electrical activity of the arm muscles. The test is repeated with the ball "falling" at varying speeds.

Earth Benefits - In space, the experiment can tell us if the astronauts adapt rapidly and use vision to compensate for the missing gravity cues, or if they have to take time to relearn this simple task. On Earth, this ball-catching experiment can be used to study individuals with neurological diseases such as Parkinson' disease, basal ganglia disorders, or cerebellar deficiency The experiment could also be used for studying motor function development in children

Visuo-Motor Coordination during Space flight

Experiment No. 008 Subject: Humans
Principal Investigator: Otmar L. Bock, Ph.D., Deutsche Sporthochschule, Koeln, Germany

How does microgravity change simple movements like grasping or pointing that on Earth require the coordination of the eyes and hands with gravity? The Visuo-Motor Coordination Facility (VCF) notes changes in the eye-hand coordination of astronauts during adaptation to microgravity. Developed by the Agence Spatiale Canadiene (Canadian Space Agency), the VCF projects visual targets onto a screen. As targets appear, the astronaut points at them as they move from place to place, grasps at them as they change in size, and tracks them as they move in a circle. During the test, the astronaut will wear a special glove that allows precise tracking of hand movements and response times. Equipped with light-emitting diodes on the fingertips, the glove provides a trail that the VCF uses to produce a three-dimensional recording. Motor skills demonstrated by the astronaut early, midway and late in the mission will be compared to record how an astronaut's nervous system adjusts to space flight.

Earth Benefits - New methods for programming the movements of robots were generated during the development of the VCF experiment. These methods could eventually improve the capacity of robots to perform complex tasks. Experiment results can also help the development of new methods for evaluating a patient's ability to use visual and pressure cues.

Role of Visual Cues in Spatial Orientation

Experiment No. 136 Subject: Humans
Principal Investigator: Charles M Oman, Ph.D., Massachusetts Institute of Technology, Cambridge, MA, USA

NASA's Virtual Environment Generator (VEG) is used to discover how the balance between visual and vestibular cues shifts toward the visual system in weightlessness. The VEG is a head-mounted display that shows computer generated virtual reality scenes generated by a three-dimensional graphics computer. The VEG also tracks the motion of the head, so scenes that are displayed appear stable when the head moves. The study looks at how astronauts use vision, the vestibular organs of the inner ear, and pressure cues to determine where they are and what they are looking at while in space.

The astronauts participating in three experiments will:
1. investigate how visual scene content and symmetry influence their perception of up or down
2. determine how quickly a moving visual scene produces the illusion of self-motion.
3. explore how the direction of perceived "down" changes their ability to recognize shapes and shadows.

Earth Benefits - Portable head-mounted virtual reality displays such as the one developed for this Neurolab experiment can be useful by providing visual prostheses for individuals with vestibular impairment. Study results can help in the design of flight simulator and virtual reality vision systems. Additional information on this experiment is available at the following web site - http://lslife.jsc.nasa.gov/ipdl/VEGhome.html

STS-90 - NEUROLAB
Vestibular Team

The Space Shuttle commander brings the orbiter to a smooth landing. The crew now feels gravity for the first time in days, perhaps weeks. They may feel unsteady on their feet and have trouble with balance. Simple tasks like walking down stairs or turning corners now may be difficult. The crew is experiencing the consequences of a successful adaptation to space. Their symptoms persist until their vestibular system -- the balance organs in the ear and all the connections they make to the eyes, brain, and muscles -- readapt to Earth.

What changes have taken place in the inner ear? How has the brain learned to ignore some information form the inner ear and reinterpret other signals to allow the astronaut to be productive in space? Special techniques are necessary to answer these questions. The inner ear resides in the densest bone in the body and does not give up its secrets easily. On Neurolab, the vestibular team will use noninvasive, but powerful, techniques to bring those answers to light.

Earth Benefits - Clinical tests of inner ear function often measure eye movements in only two directions: up-down and right-left. The eye movement system developed for Neurolab by the European Space Agency allows for measuring eye movements in all directions, allowing for more sensitive tests of inner ear performance. Experiment results may also contribute to the design of more effective rehabilitation procedures for patients with severe inner ear diseases.

Visual-Otolithic Interactions in Microgravity

Experiment No. 126 — Subject: Humans
Principal Investigator: G. R. Clement, Ph.D., CNRS/College de France, Paris, France

Spatial Orientation of the Vestibulo-Ocular Reflex

Experiment No. 047 — Subject: Humans
Principal Investigator: B. Cohen, M.D., Mount Sinai School of Medicine, New York, NY, USA

These two tightly integrated investigations study the human vestibular system outside of Earth's gravity. On Neurolab, crewmembers acting as both operators and subjects use an off-axis rotator ("rotating chair") developed by the European Space Agency (ESA) to stimulate the human vestibular system with both spinning and tilting sensations. Infrared video cameras observe and capture the eye movements that accompany the exercise.

As the centrifuge rotates at 45 rpm (to mimic the force of Earth's gravity), subjects seated on the rotator chair will initially feel rotation. This feeling quickly disappears after a few minutes. Crewmembers cannot see that they are rotating since the display seals out light from the Spacelab. Instead, they must depend on signals from their inner ear to sense motion. While the inner ear is very good at sensing the beginning or end of rotation (acceleration and deceleration), spinning at a constant rotation produces the same sensation as sitting still-with one key difference. On the rotating chair, a constant rotation while in space (i.e., without Earth's gravity pull) stimulates the inner ear the same way tilting to one side does in Earth's gravity. So, while rotating seated, the crewmembers experience not rotation, but tilt. Scientists believe, however, that in space the brain will reinterpret the information it receives from the inner ear and any changes in vestibular system response will be reflected in the eye movements.

Eye movements when watching moving stripes have been shown to reflect the presence of gravity. In space, the astronauts will look at striped patterns while rotating in the chair. Measuring eye movements can provide investigators information about how the spatial orientation of the astronauts changes and how the vestibular system is working in space. Test results taken during Neurolab will be compared with those before and after flight to provide scientists an understanding of how the brain in space reinterprets vestibular system data.

Additional information is available from the following web sites -

Http://www.cerco.ups-tlse.fr/cercoweb.htm
and
http://www.mssm.edu/ophth/mshneuro.html"

STS-90 - NEUROLAB
Sleep Team

Astronauts often sleep poorly on Space Shuttle missions. Crewmembers on Shuttle missions have reported an average sleep period of 5 to 6 hours, compared with the typical period of 7 to 8 hours on Earth. Some sleeping difficulties are expected, as astronauts often work in shifts to handle full mission schedules. There is little privacy, quarters are confined, and noises or other interruptions may occur. One survey shows that more than 50 percent of crewmembers use sleeping medication at some point during a mission.

Crewmembers also face the cumulative effects of sleep loss or the carry-over effects of a sleeping pill-a deterioration in alertness and cognitive performance during the active hours of the workday. Although sleep difficulty in space has been studied before, a clear understanding of the problem, as well as a solution, remain as missing pieces in the puzzle of how the body works in space. With frequent extended missions and the advent of the Space Station on the horizon, the issue becomes even more important.

The team will evaluate the normal sleep patterns of crew members before, during and after space flight to identify the factors which contribute to sleep disturbances associated with space flight. Included in these studies is the use of melatonin as a hypnotic agent for the treatment of sleep disturbances that occur during space flight, and the potential improvement of mood and performance of the crewmembers receiving melatonin as compared to receiving a placebo. The team will also examine crew respiration both during sleep and wakefulness.

Sleep and Respiration in Microgravity

Experiment No. 198	Subject: Humans
Principal Investigator:	John B. West, M.D., Ph.D., D.Sc., Univ. of Calif. at San Diego, La Jolla, CA, USA

Clinical Trial of Melatonin as Hypnotic for Neurolab Crew

Experiment No. 104	Subject: Humans
Principal Investigator:	Dr. C. Czeisler, M.D., Ph.D., Brigham and Women's Hospital, MA, USA

Earth Benefits - The Neurolab sleep studies benefit not only astronauts but Earth-based individuals too. The studies will help individuals with a high incidence of insomnia, such as shift workers, the elderly, and people traveling across time zones. The sleep studies have also resulted in technical advancements. A new portable system for recording sleep and respiration during space flight has been developed for the Neurolab mission that will allow sophisticated sleep studies to be performed at home, rather than in hospital diagnostic sleep laboratories. For additional experiment information, consult the following web site - http://orpheus.ucsd.edu/phys/nasalab/neurolab.html

STS-90 - NEUROLAB
Mammalian Development Team

A surgeon successfully removes a cataract from one eye of a 50-year-old man who has been blind since birth because of cataracts. When the bandages are removed, an examination reveals that the eye functions acceptably, and, more importantly, the overjoyed patient announces he can see. It soon becomes apparent, however that what the patient sees is strikingly different from what would be seen by a person with normal vision. For example, he cannot perceive size or distance. He cannot identify a face until he hears the voice to which it belongs. He sees colors and shapes, but they confuse him. What he sees makes no sense. A second operation removes the cataract from the other eye, but his vision does not improve.

Why can't the patient see? Neuroscientists find increasing evidence that if the nervous system is not exposed to normal forms of stimuli, such as vision, at specific periods during development, the nervous system will not develop properly. In the case mentioned above, the patient's eyes functioned well; however, with out the stimulation normally experienced in early childhood, the visual cortex remained underdeveloped. The eyes could see, but the brain did not get the message.

Experiments on previous space life sciences missions indicate that gravity, an ever-present stimulus in our environment on earth, may also be essential to normal development. For example, in microgravity, quail chicks failed to develop the necessary motor skills for feeding themselves. Gravity isn't essential to all development, however. Tadpoles that hatch and develop in microgravity show normal swimming behavior.

The identification of "sensitive" and "critical" periods of development will add a vital piece to the life sciences puzzle. On Neurolab, in a series of experiments that can be performed only with out the influence of gravity, investigators will study the development of muscles, the vestibular system, the cardiovascular system, and many parts of the brain. The Mammalian Development Team will use rats and mice at various stages of development.

The aim of these experiments is to provide information for understanding the effects of space flight on the normal development of the nervous system. The series of experiments will use anatomical, physiological, molecular, electrophysiological, behavioral and biochemical approaches to investigate the processes crucial for central nervous system development from shortly after the closure of the neural tube through the establishment of complex behaviors.

Earth Benefit - Just as we have the ability at birth to learn whatever language we are exposed to, we may also have the ability to adapt to whatever gravitational field we experience in early life. These abilities often exist only during a "critical period". Afterward, our potential is limited. Understanding the nature of these critical periods is important in pediatrics.

Knowledge of the critical period for developing normal vision has already changed how strabismus ("lazy eye") is treated in children. The Neurolab mammalian development experiments will expand this knowledge to the control of movement, regulation of blood pressure and maintaining balance. The experiments explore the great potential of our nervous system to adapt to whatever environmental conditions are found at birth. Information from these studies can also be applied to the development of treatments for individuals suffering from childhood neuromuscular diseases, such as muscular dystrophy, or from sustained trauma to their nerves, muscles or spinal cord.

Neuro-Thyroid Interaction on Skeletal Isomyosin Expression in 0 g
Experiment No. 103 Subject: Animals
Principal Investigator: Kenneth Baldwin, Ph.D., University of California College of Medicine at Irvine, Irvine, CA, USA

Experiment E103 will use developing rats to examine the interactive role of gravity and thyroid hormone in the production of special muscle proteins called myosin. On Earth, both gravity and thyroid hormone influence the type of myosin that is expressed, or present, in muscles. Weight-bearing muscles used to constantly support the body against the pull of gravity have more "slow" myosin than muscles used for primarily for short bursts of activity. Muscles which are more sensitive to thyroid hormone have more "fast" myosin.

The principal investigator predicts that young rats that develop in space without gravity will have more "fast" myosin in the weight-bearing muscles than those that develop on Earth. He hypothesizes that without gravity these muscles become more sensitive to the presence of thyroid hormone and further predicts that reducing the amount of this hormone will reduce the amount of "fast" myosin present. These theories will be tested by comparing the development in space and on the ground of rats with normal and deficient levels of thyroid hormones. The investigator is also interested in learning if there is a critical period for muscle development during which the changes caused by microgravity cannot be reversed once the animal returns to Earth.

Earth Benefits - Exposure to the space environment leads to muscle atrophy (wasting) similar to that seen during prolonged periods of bedrest or during certain diseases. Better understanding of how gravity impacts important developmental and maturation processes in muscles could provide insights that could prevent muscle wasting for bed ridden patients or lead to treatments of muscle wasting diseases on Earth.

Neuronal Development Under Conditions of Space Flight
Experiment No. 93 Subject: Animals
Principal Investigator: Kenneth S. Kosik, Brigham and Women's Hospital, Boston, MA, USA

It is well known that the proper development of the nervous system requires sensory input. Experiment 123 is designed to determine whether the sensory information provided by gravity after birth is necessary for the development of spatial ability. Spatial ability is the ability to know where we are in relation to our environment . The first step in answering this question is to study how exposure to microgravity affects the structure and function of brain areas, particularly the hippocampus, involved in spatial memory.

To complete this study, young rats in two age groups (eight or 14 days of age at launch) undergoing critical periods of development will either fly in space or remain on the ground. Following the mission, tissue from the brain will be collected and the number of synapses (communication structures between nerve cells) found in the hippocampus will be compared between the flight and ground-based control animals. The expression, or presence, of certain key molecules that appear in the mature brain will also be measured to see how the chemical function of the brain may have changed as a result of spaceflight. In addition, after recovery, the rats' ability to acquire spatial memory will be tested by teaching them to run a maze and the physiology of their hippocampal cells will be studied by recording their electrical activity.

Earth Benefits - This investigation will provide insights into early brain development. An enhanced understanding of early brain development is crucial to providing infants and children an environment which allows the brain to attain its maximum capacity. Applications to current pressing medical conditions are also expected because spatial ability is frequently affected in a variety of brain diseases, including Alzheimer's disease and stroke.

Reduced Gravity: Effects in the Developing Nervous System
Experiment No. 93 Subject: Animals
Principal Investigator: Richard S. Nowakowski, University of Medicine and Dentistry of New York, USA

Proliferation of nerve cells through a well-choreographed series of "birthdays" and subsequent cell migrations is a necessary process for normal brain development. Experiment E093 will study this process in space to determine if gravity is required for normal brain development.

For this experiment, the investigator is focusing on the early development of the cerebral cortex in mice embryos. The cerebral cortex is a well-studied structure for which there is a great deal known about normal development. During the investigation, two markers of cell proliferation will be used to: 1) label the cerebral cortex nerve cells at their "birth" and 2) to follow them as they migrate through the developing brain. The development that occurs in space will be compared with that of normal development that occurs on the ground. Understanding whether the brain can develop normally in space will be critical to determining if colonization of space – where animals may need to be produced for food and people may be born – is possible.

Although mice are the most commonly used research model on the ground, Neurolab is the first time that they have been flown on the Space Shuttle (Rats, however, have been used in on-orbit shuttle mission experiments before). The pregnant animals used in this study will be housed in an Animal Enclosure Module (AEM) placed in the middeck area of the Shuttle. The AEM, built by NASA Ames Research Center, has been specially modified for Neurolab to allow the crew to access the animals as required to complete this research.

Microgravity and Development of Vestibular Circuits
Experiment No. 143 Subject: Animals
Principal Investigator: Jacqueline Raymond, University de Montpellier II, Montpellier, France

Neuroscientists are finding increasing evidence that if the nervous system is not exposed to normal forms of stimulation at specific, critical periods of development, it will not develop properly. Experiment 143 will determine if exposure to gravity is a required form of stimulation for development of normal structure and function of the vestibular system. The vestibular system is responsible for helping animals and people maintain their balance.

To complete this study, tissue will be collected at several time points during and following the mission from young rats in two age groups (eight or 14 days of age at launch), either exposed to space or remaining on the ground. The interval between launch and landing represents a critical developmental period for the animals that is marked by rapid neural and motor development. The investigator anticipates that animals developing in space will not develop normally when compared with those on the ground, and that younger animals will show greater affects of exposure to microgravity than older animals.

Earth Benefits - Information obtained from this study will provide greater understanding of how the vestibular system adapts to changing environments. This may be particularly beneficial for learning how to treat patients on Earth whose vestibular system may be damaged due to illness or injury.

Effects of Microgravity on Neuromuscular Development
Experiment No. 122 Subject: Animals
Principal Investigator: Danny A. Riley, Medical College of Wisconsin Milwaukee, WI, USA

Experiment 122 will examine if there is a critical period when gravity is required for the normal development of muscles in young rats. The fundamental hypothesis is that without gravity the "anti-gravity" muscles predominantly used for weight-bearing will not develop normally, whereas locomotor muscles predominantly used for movement will.

To test this hypothesis the development of muscles and their controlling nerve cells will be monitored in young rats either flown in space or maintained on the ground over the duration of the mission. At several time-points during and after the mission an anti-gravity muscle, the soleus, and a locomotor muscle, the extensor digitorum longus will be injected with a fluorescent label. The label will be transported to the spinal cord nerve cells and then the muscles and spinal cord will be collected. The investigator predicts that in the absence of gravity the soleus muscle will have motoneurons and muscle fibers that are smaller than normal, that the motoneurons will show reduced levels of key metabolic enzymes, and that muscle fibers will express proteins characteristic of immature fibers. He also predicts that the effects of spaceflight will persist into adulthood.

Earth Benefits - Results from this study will have strong implications for rearing normal animals, including humans, in the microgravity environment of space, and will further our understanding of the importance of weight bearing activity for motor system development of human infants on Earth. Premature infants, living in incubators, are deprived of exercising their legs against the uterine wall, and infants may have diseases that limit normal weight bearing activity. To what degree compromised weight bearing delays or permanently alters normal neuromuscular development is unknown. The studies of neonatal rats will provide valuable insights into the role of gravity in the development process and if appropriate, may indicate exercise procedures to promote normal development in compromised infants.

STS-90 - NEUROLAB
Neuronal Plasticity Team

Life evolved in earth's gravitational field, and animals learn tasks, such as walking, under the force of gravity. When the gravity load is reduced, as it is in space, the nervous system is challenged. The inner ear, which senses gravity, no longer provides meaningful information identifying "up" or "down." Because the body is weightless, nerves in the joints no longer sense the weight of a limb. When a person is floating, walking is not necessary, and maintaining balance is not important. The brain must relearn many tasks to compensate for this new environment. The fact that people can function well in space shows that the nervous system can compensate effectively. This is accomplished through neuronal plasticity, a phenomenon in which neurons react to changed conditions by making new connections or using existing connections in different ways. At the cellular level, neuronal plasticity *is* learning.

How plasticity takes place is a significant question in neuroscience. On Neurolab, investigators will study neuronal plasticity to understand how balance, daily rhythms (such as sleep/wake cycles), and the control of movement change in microgravity. Using rats as subjects, Neurolab investigators will explore how learning occurs in space by measuring changes that take place in the central nervous system. The science in this team will examine the neural and physiological changes during and following space flight to address the response of the adult rodent central nervous system to altered gravity.

Earth Benefits - Experiments on vestibular adaptation will yield a better understanding of balance disorders, which affect more than 90 million Americans. Experiments on circadian rhythms could yield valuable data to researchers seeking the causes of jet lag, insomnia and mental disorders such as winter depression. This data is also applicable to aging populations and shift workers, both of whom experience changes in circadian rhythms. Reconstructing the images from one of these experiments has already led to the development of a Biocomputation Center at the Ames Research Center. The computers there now are also being used to develop vital surgery techniques, a key application and NASA spinoff for the three-dimensional reconstruction software developed there.

CNS Control of Rhythms and Homeostasis During Spaceflight

Experiment No. 132 Subjects: Animals
Principal Investigator: Charles Fuller, Ph.D., University California, Davis
Davis, CA, USA

Several body systems show a natural daily, or circadian rhythm that is synchronized with the 24-hour day. The goal of the E132 flight experiment is to determine how space flight affects the timing and intensity of circadian rhythms of body temperature, heart rate, and activity in rats exposed to different light cycles. The effects of space flight on the neurons in the brain that make up the circadian clock will also be observed by measuring immediate early gene (IEG) activation in response to light/dark stimuli. IEGs, a newly-discovered class of intracellular messengers that contain instructions for the production of proteins, come in several forms. On Neurolab, the investigator will focus on the IEGs that can serve as early markers of neuronal plasticity. By identifying the presence of these IEGs in microgravity, the investigator will know where in the brain plasticity – or adaptation to the new environment – is occurring.

To complete this study the heart rate, body temperature and activity level of mature rats housed in the Research Animal Holding Facility (RAHF) under different lighting conditions will be monitored. Two times during the mission the animals will be given a light pulse to stimulate the production of IEG. Shortly after the light pulse is administered tissues will be collected to determine the presence of IEG in the brain.

Earth Benefits - Experiments leading to greater understanding of circadian rhythms could help researchers seeking the causes of jet lag, insomnia and mental disorders such as winter depression.

Anatomical Studies of Central Vestibular Adaptation
Experiment No. 132 Subject: Animals
Principal Investigator: Gay R. Holstein, Mount Sinai School of Medicine, New York, NY

Experiment 127 will identify the structural and chemical changes that occur in the cerebellum as a result of adaption to microgravity and readaptation to Earth's gravity. The cerebellum is the part of the brain that is critical for maintaining balance and for processing information from the limbs so that they may be moved smoothly. Upon entering the weightless environment of space, the gravity cues that the cerebellum relies upon to function normally are taken away. After an initial period of adjustment, the cerebellum learns to function in the new environment. The ability of the nervous system to adjust to new environments is referred to as plasticity. The studies conducted by this investigator will help identify the cellular bases for the plasticity that occurs in the system of balance and equilibrium.

To complete these studies, the cerebella of adult rats in space and on the ground will be removed at two time-points during, and immediately following, the mission. The tissues collected in space will be preserved and returned to Earth for later analyses to determine how the structure and function of the cerebellum may have changed with short or longer exposures to microgravity. By comparing the tissue from ground-based rats with those obtained from rats during or following the mission, it wil be possible to localize, characterize and quantify the site(s) and synapses (communication structures between nerve cells) that mediate plasticity.

Earth Benefits - Approximately 12.5 million Americans over the age of 65 are afflicted by balance disorders, including vertigo and dizziness. Data from this study may provide increased understanding of the causes of balance disorders which, in turn, could lead to possible remedies.

Multidisciplinary Studies of Neural Plasticity in Space
Experiment No. 85 Subject: Animals
Principal Investigator: Muriel D. Ross, Ph.D., NASA Ames Research Center, Moffett Field, CA, USA

The neurovestibular system, which helps people and animals maintain balance, is very sensitive to gravity. Experiment 085 will employ a number of modern methods to obtain information on how spaceflight affects the structure and function of the neurovestibular system, particularly the gravity-sensing organs in the inner ear.

As a result of the investigator's previous research on the Spacelab Life Sciences-1 (SLS-1) and SLS-2 missions, scientists now know that the nerve cells of the inner ear experience plasticity - the ability to adapt or change appropriately to new environments. On Neurolab, data collected before, during and after the mission will help scientists to understand the implications of these changes, when they begin, and how they occur. The studies should also help answer the question whether readaptation to Earth is independent of, or correlated with, the length of time of exposure to altered gravity.

Earth Benefits - The computer software developed by the investigator to help analyze data from space has found widespread application beyond the field of neuroscience. For example, the investigator is currently working with the Department of Reconstructive Surgery at Stanford University to produce an interactive, collaborative virtual environment for planning of craniofacial surgeries. A pilot project involves producing computer-based reconstructions of the facial structure of real patients and creating a virtual environment in which the surgeon may simulate and plan the operation.

STS-90 - NEUROLAB
Aquatic Team

How does the vestibular system adjust to the microgravity of space? Do physiological changes occur in the components of the gravity sensors? Are the signals sent from the inner ear to the brain altered? If alterations occur, does behavior change? Nuerolab will seek answers to these questions through a series of experiments that focus on the gravity sensing system in snails and fish.

The gravity-sensing system in vertebrates from fish to humans has the same basic structure. In humans, this system is a component of the inner ear. An even simpler system, which is easier to analyze and develops faster, exists in snails. The gravity-sensing component is lined with hair cells that send signals to the brain when they are as triggered. The "triggers" are small rock-like particles of calcium carbonate, referred to the statoliths in snails and otoliths in fish and humans. With the tug of gravity, these triggers weigh down upon and bend different groups of hair cells. Activated by this "bending," the hair cells then send orientation signals to the brain.

The Aquatic discipline team is made up of two investigations using aquatic species as experimental subjects. The investigations use different species, housed in separate facilities.

Earth Benefits - Data from the aquatic experiments on Neurolab may disclose the mechanisms at work in various forms of motion sickness experienced by many people on Earth. The studies may also help explain why aging otoliths become smaller. Further benefits include the use and perfection of the sieve or wafer electrode that is used to record nerve impulses. This electrode offers potential use as a connection to the nervous system in people with deafness caused by hair cell damage. It also could be used as an interface to signal motor prostheses how and when to move.

Chronic Recording of Otolith Nerves in Microgravity
Experiment No. 88 Subject: Animals
Principal Investigator: Stephen M. Highstein, Ph.D., Washington University School of Medicine, Saint Louis, MO, USA

The ability of neurons to adapt to changed environments by making new connections or using existing connections in different ways is referred to as "neuronal plasticity" and is of significant interest to neuroscientists. The E088 investigation will use Oyster Toadfish (*Opsanus tau*) to determine if the otolith organs, which sense gravity and body position, experience plasticity. By studying outgoing nerve traffic from the otolith organ to the brain, the investigator should be able to determine the type of adaptation that occurs and the time frame over which it takes place.

To collect this data, multi-channel wafer electrodes will be placed in small cuts in the nerves connecting the inner ear with the brain of the toadfish. The individual fibers, called axons, of the nerve will regenerate through the pores in the electrode to permit longterm recordings of the nerve activity. The nerve activity data will be collected and measured using a wireless telemetry system developed by the National Space Development Agency of Japan (NASDA). The fish themselves will be housed in another new piece of hardware, also developed by NASDA, the Vestibular Function Experiment Unit (VFEU).

Earth Benefits - Fish vestibular systems are very similar to those of other animals, including humans. By recording data from the nerves of the inner ears of fish, the investigator should be able to understand the changes in the same signals sent by the astronauts' inner ears as they adapt to microgravity. This information could shed light on the causes of space motion sickness experienced by astronauts and motion sickness experienced on Earth. The wafer electrode technology used in this experiment may have clinical applications for patients suffering from nerve disorders or injuries.

Development of Vestibular Organs in Microgravity
Experiment No. 4 Subject: Animals
Principal Investigator: Michael L. Wiederhold, Ph.D., University of Texas Health

Science Center at San Antonio, San Antonio, TX, USA

In experiment E004, fresh-water snails (*Biomphalaria glabrata*) and swordtail fish (*Xiphophorus helleri*) at various developmental stages will be used to study how microgravity affects the formation of statoliths and otoliths, the dense calcium masses found in the gravity-sensing organs of snails and vertebrates (e.g., fish), respectively.

The investigator predicts that snails developing without gravity will produce larger than normal calcium masses when compared to those developing on the ground. Video taken inflight and on the ground will be used to correlate how changes in the statoliths may affect the behavior of the snails. Tissues from some animals will be collected immediately following the mission, other animals will monitored for a period after the mission to see if the statoliths return to normal.

Earth Benefits - These studies will offer new insight into the mechanisms controlling otolith formation and maintenance. Recent studies indicate that calcium loss from the otoliths may contribute to balance problems in elderly humans. Falls, which can be quite harmful to older individuals, are a common side effect of balance problems.

STS-90 - NEUROLAB
Neurobiology Team

In any of the experiments on Neurolab, investigators are searching for pieces to one particular space life sciences puzzle-the puzzle of how much of normal development is preprogrammed in genes, and how much depends on cues from the environment (like gravity).

As it turns out, the familiar domestic cricket (Acheta domesticus) can help. Crickets have simple gravity sensors connected to a simple and well-studied nervous system. This means that development of the gravity sensors and connections they make to the nervous system can be studied comprehensively both with and without gravity. The crickets develop rapidly, making them ideal for studies on a 16-day flight.

Also, the cricket has another sensory system located next to gravity receptors. This system is comprised of wind(or air current) receptors, and there is no reason to expect that these should change without gravity. So, by comparing the development of the gravity receptors and their connections, the effect of microgravity will be revealed. After the flight, the consequence of developing in space can be measured. Crickets roll their heads when tilted, and this reflex is activated by the gravity sensing system. By studying head rolling after the flight, investigators can measure the behavioral consequences of having a nervous system that was built in space.

Development of an Insect Gravity Sensory System
Experiment No. 89 Subject: Animals
Principal Investigator: Eberhard R. Horn, Ph.D., University of Ulm, Ulm, Germany

Crickets have gravity sensors, called cerci, that are connected to a simple and well-studied nervous system. Experiment E089 will use crickets to determine if a sensory organ known to be responsive to gravity will develop normally in microgravity. The investigator anticipates that during a critical period of early life, exposure to microgravity will interfere with the genetic program that controls the development of the gravity sensory system, and therefore, the systems will not develop normally. He also anticipates that normal regeneration of the gravity sensing system, a process readily accomplished on Earth, depends on gravity to procede normally.

To conduct this study, crickets at several early developmental stages (eggs and larvae) will be housed in the Botany Experiment Incubator (BOTEX), a special incubator developed by the German Space Agency. In the BOTEX, developing crickets can be placed in a rotating compartment that simulates Earth's gravity, or in containers that experience microgravity conditions. The development of the gravity sensors and the connections they make to the nervous system will be compared between the animals that experience the two different environmental conditions. The efficiency and accuracy of the connections that develop in space will be assessed by evaluating behavioral changes of the cricket and measuring the rate at which the cricket's neural pathways transmit a sensory stimulus. Similar tests will be used to measure the success of the regeneration experiment.

Insects, like the cricket, offer useful model systems for the development of the nervous system because their central neurons can be easily identified and affects of external stimuli ascertained. The project will contribute to our understanding of the relative importance of the environment and how external stimuli (like gravity) can intefere with genetic programming and affect normal development.

Earth Benefits - How much of normal development is preprogrammed in our genetic code, and how much can be modified by our environment and experiences? These are two old and puzzling questions. The Neurobiology team will provide information on the relative importance of the environment and other external stimuli (like gravity) on nervous system development. The gravity system of crickets serves as a model to investigate the general effects of altered gravitational conditions on the development of the structure, function and efficiency of a gravity sensory system. Insects offer useful model systems because their central neurons can be easily identified.

SCIENCE GLOSSARY

Acceleration
Acceleration is the rate of change of velocity with respect to time.

Autonomic nervous system
The autonomic nervous system is the part of the nervous system that supplies stimulation to the involuntary muscles, like the smooth and cardiac muscles, and to the glands. The autonomic nervous system is controlled principally by parts of the brain stem and the hypothalamus (a part of the brain).

Biochemical
Biochemical refers to the chemical reactions that occur within a living organism. An example of the chemical reactions includes enzymes that breakdown or build biological molecules.

Blood pressure
Blood pressure is the pressure exerted by the flow of blood through the arteries of the body. This pressure is greatest during the contraction of the ventricles of the heart (systolic pressure), which forces blood into the arterial system. Pressure falls to its lowest level when the heart is filling with blood (diastolic pressure).

Calcium
Calcium is a chemical element essential for the normal development and functioning of the body, typically present in the blood at a concentration of about 10mg/100ml. Calcium is an important constituent of bones and teeth, and it is essential for many metabolic processes, including nerve function, muscle contraction, and blood clotting.

Cardiovascular
Cardiovascular means pertaining to the heart and the blood vessels.

Cardiovascular system
The cardiovascular system is the system of the heart and blood vessels.

Central Nervous System (CNS)
The Central Nervous System consists of the brain and the spinal cord; the CNS is responsible for the integration of all nervous activities

Centrifuge
A centrifuge is a device that rotates at various speeds about a fixed, central point. It can separate liquids from solids or liquids of different densities by way of the centrifugal force resulting from its rotation.

Circadian rhythm
Circadian rhythms are biological rhythms or variations that repeat with a cycle of about 24 hours. They are also known as Diurnal Rhythms.

Cortex
The cortex of an organ refers to the outer portion (layer) of the organ.

Nervous system
The nervous system is the vast network of cells specialized to carry information (in the form of nerve impulses) to and from all parts of the body in order to bring about bodily activity. In vertebrates, the brain and spinal cord together form the central nervous system; the remaining nervous tissue is known as the peripheral nervous system and includes the autonomic nervous system, which is itself divided into the sympathetic and parasympathetic nervous systems. The basic function unit of the nervous system is the neuron (nerve cell).

Neural
Neural means pertaining to the nervous system.

Neuronal plasticity
Neuronal plasticity is a phenomenon in which neurons react to changed conditions by making new connecting or using existing connections in different ways.

Neuroscience
Neuroscience is any one of the various branches of science concerned with growth, development and function of the nervous system.

Neurovestibular

Neurovestibular relates to the interaction between the brain and the vestibular organ, located in the inner ear. The vestibular apparatus is responsible for balance. It consists of three semicircular canals, which detect movements of the head, and the utriculus and sacculus, which detect the position of the head.

Noninvasive

Noninvasive describes diagnostic procedures which do not involve the insertion of devices into the body or require penetration of the skin. Common noninvasive techniques are ultrasound or EKG.

Orthostatic intolerance

Orthostatic intolerance is a condition of lightheadedness, possibly leading to fainting, that occurs when an upright position is assumed. It is caused by low blood pressure and an inadequate supply of blood reaching the brain. Astronauts often experience temporary orthostatic intolerance when remaining upright after returning from stays in space, since their blood volume is reduced in weightlessness and the pull of gravity does not allow blood to reach their heads.

Otolith

An otolith (or otoconium) is one of the small particles of calcium carbonate in the saccule or utricle of the inner ear. Pressure of the otoliths on the hair cells of the macula provide sensory inputs about acceleration and gravity.

Pathology

Pathology is the study of disease processes with the aim of understanding their nature and causes. This is achieved by observing samples of blood, urine, feces, and diseased tissuse obtained from the living patient or from an autopsy, by the use of X-rays and by many other techniques.

Physiological

Physiological means of or relating to physiology, the science that studies the function of the body and the vital processes of living things, whether animal or plant.

Physiology

Physiology is the study of the functions or vital processes of living things whether animal or plant.

Prosthesis

A prosthesis (plural prostheses) is any artificial device that is attached to the body as an aid. Prostheses include dentures, artificial limbs, hearing aids, implanted pacemakers.

Protein

Proteins are one of a group of organic compounds of carbon, hydrogen, oxygen and nitrogen with sulfur and phosphorus possibly present. The protein molecule is a complex structure made up of one or more chains of amino acids, which are linked by peptide bonds. Proteins are essential constituents of the body; they form the structural material of muscles, tissues, organs, etc. and are equally important as regulators of function as enzymes and hormones; they can also be converted into glucose and used as an energy source by the body.

Respiration

Respiration is the act of breathing air into and oust of the lung so that vital gases can be absorbed into the body. In plant physiology, respiration refers to the cellular breakdown of sugar and other foods, accompanied by the release of energy.

Sensory

"Sensory" relates to the input into the nervous system from the nerve receptors of the body; it is any information carried from receptors throughout the body toward the brain and spinal cord.

Sensory-motor

Sensory-motor relates to a nerve possessing both sensory and motor functions.

Soleus

The soleus is the broad, flat muscle located in the lower leg, beneath the calf muscle, that flexes the foot so that the toes paint downward.

Spatial orientation

Spatial orientation refers to the process of aligning or positioning in a three-dimensional space with respect to a specific direction or reference system.

Spinal cord
The spinal cord is the portion of the central nervous system enclosed in the vertebral column, or back, consisting of nerve cells and bundles of nerves connecting all parts of the body with the brain.

Statolith
A statolith is a crystal found in the ear, and is made up of particles of calcium carbonate and protein. Press in man, animals, and plants, they are responsible for the sense of equilibrium.

Stimuli
A stimulus (plural stimuli) is a change in the external or internal environment of an organism that provokes a physiological or behavioral response in the organism.

Velocity
Velocity is the rate of movement, or more specifically, the distance traveled per unit of time.

Vestibular
Vestibular means relating to the vestibule of the ear, a cavity situated at the entrance to the bony labyrinth (a part of the inner ear) that contains the saccule and utricle – the organs of equilibrium.

Visual
Visual refers to the sense of vision, the sense that enables perception of objects in the environment by means of the eyes.

STS-90 SMALL SHUTTLE PAYLOADS

Flying on the STS-90 Space Shuttle mission will be one Hitchhiker and three Get Away Special (GAS) payloads which were manifested by the Shuttle Small Payloads Project (SSPP) at the Goddard Space Flight Center in Greenbelt, Md. Below is a brief description of those experiments.

Shuttle Vibration Forces

The Shuttle Vibration Forces (SVF) experiment will measure the dynamic forces acting between the Space Shuttle and a canister attached to the Shuttle sidewall during two upcoming Shuttle flights: STS-90 and STS-96. In previous Shuttle flights, the vibration motion at various positions in the cargo bay has been measured, but the SVF experiment will provide the very first measurements of the dynamic forces acting on Shuttle equipment. The SVF data, together with a new vibration testing method, will enable NASA to fly more sophisticated equipment on the Shuttle, at less cost.

The powerful rocket engines used on the Space Shuttle, and other launch vehicles, generate a great deal of noise and vibration at lift-off. All of the Shuttle equipment must be designed for this severe environment, and most of the cargo is subjected to very severe vibration testing to insure that it will survive. Although aerospace equipment has become increasingly sophisticated, vibration testing methods have not changed substantially in 50 years. As a result, conventional vibration testing methods are not well suited to lightweight, and sometimes delicate, aerospace equipment. Equipment which could survive space flight just fine, often fails during vibration testing, which leads to a waste of effort and money because redesign and retesting must be performed.

A new, more realistic and benign method of vibration testing has been developed and is currently being used on many NASA flight programs. The new method involves limiting the force in the vibration test to that predicted for flight.
The force data provided by the SVF experiment is needed to validate the new method and, if possible, to further reduce the severity of aerospace vibration tests.

The principal investigator for SVF is Terry Scharton from the Jet Propulsion Laboratory, Pasadena, Calif. The mission manager is Ben Liu from Goddard.

Get Away Specials

G-197

NASA Get Away Special (GAS) payload G-197 on the STS-90 Neurolab mission is an experiment featuring the world's smallest version of a new type of refrigerator. Known as the pulse tube refrigerator, the device was designed and built under a Cooperative Research and Development Agreement between Lockheed Martin Astronautics, Denver, and the National Institute of Standards and Technology (NIST), Boulder, Colo. Significant contributions to the project also were provided by the NASA Ames Research Center, Mountain View, Calif.

The primary objectives of this experiment are to demonstrate the pulse tube cooling technology in the zero gravity environment of space and to gain operational experience with the smallest such cryocooler yet built.

Pulse Tube refrigerators, or cryocoolers, can be used to cool infrared sensors and other devices to approximately minus 315 degrees Fahrenhe it. Very cold sensors are used in space based research and are needed to study the temperature variations in the atmosphere and oceans to aid in the understanding of the ozone hole, global warming and long range weather forecasting.

Pulse tube cryocoolers have advantages over several other types of coolers. Because pulse tube cryocoolers have fewer moving parts, they produce lower vibration and use simpler electronics. These features contribute to higher reliability, a longer functional lifetime and lower electromagnetic emissions.

The cryocooler in this experiment is approximately five inches long, weighs about two pounds and is powered by batteries. The experiment weighs 209 pounds (including batteries, control electronics and the onboard computer to record data) and fits into a five cubic foot GAS can located in the Shuttle's cargo bay.

The payload manager for G-197 is Dr. Daniel Ladner from Lockheed Martin Astronautics. Drs. Ladner and Ray Radebaugh are from NIST. The mission manager is Susan Olden from Goddard. Lee Shiflett is the technical manager, also from Goddard.

G-772

Students at the University of Colorado, Boulder, Colo., have designed a payload that will analyze the gentle collisions of dust particles in space which may shed new light on the sources of dust in planetary rings.

Collisions into Dust Experiment or COLLIDE will consist of six self-contained experiments, each holding a spring-loaded sphere projectile and a tray of ground up basalt that simulates space dust. The projectiles will spring from small doors in each container and softly strike the dust anchored in the box-like devices. Two camcorders will record all the activity on videotape, allowing the experimenters to analyze the amount, direction and speed of dust ejected from the target trays by each impactor.

The experiment will feature four different impact speeds and two different spherical impactor sizes. Powered by 18 size D batteries, the experiments will take 25 minutes to complete. The video will then be analized after return to the ground.

Evolution of planetary rings is controlled by collisions between ring particles. Similar collisions occurred in the early stages of planet formation. These collisions are slow and gentle. The ring particles are covered with a layer of dust from micrometeroid bombardment. Some dust is released when larger particles collide, resulting in dust rings and in the loss of orbital energy of the larger particles. The gravity of the large particles is small, so the phenomenon of dust release in gentle collisions between these particles requires a microgravity environment. Although dust is present in the rings of the four gaseous giant planets, how dust is knocked off larger ring particles a meter or more across during their continuous collisions with each other remains a mystery.

The principal investigator for this payload is Joshua Colwell from the University of Colorado at Boulder. Susan Olden, from Goddard, is the mission manager. Charles Knapp, also from Goddard is the technical manager.

G-744

GAS payload G-744 is from Sierra College in Rocklin, Calif. The objective of this experiment is to take ozone measurements of the Earth's upper atmosphere in the ultraviolet 200 nanometer to 400 nanometer spectral range using a Charge Coupled Device based spectrometer. A Charge Coupled Device camera also will fly as part of the experiment and provide target verification for the spectrometer. The GAS carrier top plate will be modified to provide two optical ports for the instruments.

The payload requires a minimum of two complete back-to-back day side passes with the Shuttle Orbiter to take data. Just prior to the Orbiter attaining the required attitude, the payload is to be activated. The spectrometer will autonomously begin taking data when the Earth is in the instrument field of view as detected by ultraviolet intensity. Simultaneously, the photographic camera will image the area where data is being collected. The payload will be deactivated as late as possible in the mission.

The principal investigator for G-744 is Michael Dobeck from Sierra College. Serving as the mission manager is Susan Olden from Goddard. Charles Knapp, also from Goddard, is the technical manager.

BIOREACTOR DEMONSTRATION SYSTEM - 04

The Bioreactor Demonstration System-04 (BDS-04) / Biotechnology Specimen Temperature Controller (BSTC) is a reconfigurable, multichamber, temperature-controlled, static tissue culture apparatus. On the STS-90 mission the BDS system will house two experiments, the Human Renal Cell experiment and The Microgravity Induced Differentiation of HL-60 Promyelocytic Leukemia cells.

The BDS-04 is a single chassis that is divided into two sections. The first section contains the control computer, power supplies, signal conditioners and interface electronics. The second section contains four insulated incubation/refrigeration modules. These modules are heated and cooled via Thermoelectric Coolers. Each module can hold up to three tissue culture bags containing media and cells. These tissue culture bags which hold 25 ml media and cells per section, have two septums for sampling and fixing or inoculating the contents. BDS-04 temperature control range is from 4° to 50° C. BDS-04 will be operated at 17° C to 36° C during the STS-90 mission.

Human Renal Cell experiment

This experiment will evalaute renal cells in their differentiation or maturity of function, the production of erythropoietin (EPO) and the production of 1-25-diOH Vitamin D3.

The data gathered by this experiment is important because presently there are no complex models of human renal cell function in vitro(Tissue culture). Scientist have found that in simulated microgravity the cells mature and act like the cells found in the human body. Investigators expect to see an enhancement of this development in actual Microgravity. This enhancement allows the cell to produce renal hormones needed in the normal human physiology.

EPO and Vitamin D3 are two very important renal hormones which are given to patients with diseases such as kidney disease, AIDS, Cancer chemotherapy patents, and other diseases of immune function. These hormones are essential to normal health. The total US market for these two hormones is 2.5 billion dollars per year. Any improvement in the production of these hormones will advance the ability to treat numerous diseases in the US and the world.

The Microgravity Induced Differentiation of HL-60 Promyelocytic Leukemia cells.

This experiment will study the differentiation (maturation) of bone marrow like cells which have the ability to become a myriad of immune cells found in the human physiology. The study of these cells and the cells which are produced will provide essential knowledge about this process of differentiation. Immune cells which mature from the original cells can be found in the blood, bone marrow and immune system and are responsible for fighting disease. These types of cells often need to be replaced in patients which have undergone chemotherapy, radiation therapy, or have experienced diseases of the immune system. An understanding of how these cells are formed is critical to development of new strategies for combating disease.

STS-90 CREW BIOGRAPHIES

RICHARD A. SEARFOSS (Lieutenant Colonel, USAF, Colonel Selectee)
STS-90 Mission Commander

PERSONAL DATA - Born June 5, 1956, in Mount Clemens, Michigan, but considers Portsmouth, New Hampshire, to be his hometown. Married; three children. He enjoys running, soccer, radio-controlled model aircraft, Scouting, backpacking, and classical music.

EDUCATION - Graduated from Portsmouth Senior High School, Portsmouth, New Hampshire in 1974; received a bachelor of science degree in aeronautical engineering from the USAF Academy in 1978, and a master of science degree in aeronautics from the California Institute of Technology on a National Science Foundation Fellowship in 1979.

ORGANIZATIONS - National Eagle Scout Association, Air Force Association, Academy of Model Aeronautics.

SPECIAL HONORS - Awarded the Harmon, Fairchild, Price and Tober Awards (top overall, academic, engineering, and aeronautical engineering graduate), United States Air Force Academy Class of 1978. Distinguished graduate, USAF Fighter Weapons School. Named the Tactical Air Command F-111 Instructor Pilot of the Year, 1985. Recipient of the Air Force Commendation Medal, the Air Force Meritorious Service Medal, the Defense Superior Service Medal, and the Defense Meritorious Service Medal.

EXPERIENCE - Searfoss graduated in 1980 from Undergraduate Pilot Training at Williams Air Force Base, Arizona. From 1981-1984, he flew the F-111F operationally at RAF Lakenheath, England, followed by a tour at Mountain Home AFB, Idaho, where he was an F-111A instructor pilot and weapons officer until 1987. In 1988 he attended the U.S. Naval Test Pilot School, Patuxent River, Maryland, as a USAF exchange officer. He was a flight instructor at the U.S. Air Force Test Pilot School at Edwards AFB, California, when selected for the astronaut program.

He has logged over 4,200 hours flying time in 56 different types of aircraft and over 557 hours in space.

Selected by NASA in January 1990, Searfoss became an astronaut in July 1991. Initially assigned to the Astronaut Office Mission Support Branch, Searfoss was part of a team responsible for crew ingress/strap-in prior to launch and crew egress after landing. He was subsequently assigned to flight software verification in the Shuttle Avionics Integration Laboratory (SAIL). Additionally, he has served as the Astronaut Office representative for both flight crew procedures and Shuttle computer software development. Most recently, he has served as the Astronaut Office Vehicle System and Operations Branch Chief, leading a team of several astronauts and support engineers working on Shuttle and International Space Station systems development, rendezvous and landing/rollout operations, and advanced projects initiatives.

Searfoss served as STS-58 pilot on the seven-person life science research mission aboard the Space Shuttle Columbia, launching from the Kennedy Space Center on October 18, 1993, and landing at Edwards Air Force Base on November 1, 1993. The crew performed neurovestibular, cardiovascular, cardiopulmonary, metabolic, and musculoskeletal medical experiments on themselves and 48 rats, expanding our knowledge of human and animal physiology both on earth and in space flight. In addition, the crew performed 16 engineering tests aboard the Orbiter Columbia and 20 Extended Duration Orbiter Medical Project experiments. The mission was accomplished in 225 orbits of the Earth.

Launching March 22, 1996, Searfoss flew his second mission as pilot of STS-76 aboard the Space Shuttle Atlantis. During this nine-day mission the STS-76 crew performed the third docking of an American spacecraft with the Russian space station Mir. In support of a joint U.S./Russian program, the crew transported to Mir nearly two tons of water, food, supplies, and scientific equipment, as well as U.S. Astronaut Shannon Lucid to begin her six-month stay in space. STS-76 included the first ever spacewalk on a combined Space Shuttle-Space Station complex. The flight crew also conducted scientific investigations, including European Space Agency sponsored biology experiments, the Kidsat earth observations project, and several engineering flight tests. Completed in 145 orbits, STS-76 landed at Edwards Air Force Base, California, on March 31, 1996.

SCOTT D. ALTMAN (Lieutenant Commander, USN)
STS-90 Pilot

PERSONAL DATA - Born August 15, 1959 in Lincoln, Illinois. Married to the former Jill Shannon Loomer of Tucson, Arizona. They have three children. Enjoys classic automobiles, flying and computers. Avid reader and sports fan/participant. Hometown is Pekin, Illinois, where his parents, Fred and Sharon Altman, currently reside. Her father, Larry Loomer, resides in San Diego, California. Her mother, Donna Loomer, is deceased.

EDUCATION - Graduated from Pekin Community High School, Pekin, Illinois in 1977; received bachelor of science degree in aeronautical and astronautical engineering from the University of Illinois in May 1981, and a master of science degree in aeronautical engineering from the Naval Postgraduate School in June 1990.

ORGANIZATIONS - University of Illinois Alumni Association, Sigma Chi Alumni Association, life member Association of Naval Aviation and Military Order of the World Wars, full member Society of Experimental Test Pilots.

SPECIAL HONORS - Navy Strike/Flight Air Medal, Navy Commendation Medal, Navy Achievement Medal, 1987 Award winner for Outstanding Achievement in Tactical Aviation as selected by the Association of Naval Aviation.

EXPERIENCE - Altman was commissioned an Ensign in the United States Navy following completion of Aviation Reserve Officer Candidate School in Pensacola, Florida, in August 1981. Following training in Florida and Texas, he received his Navy wings of gold in February 1983 and was ordered to NAS Miramar in San Diego, California, to fly the F-14. Attached to Fighter Squadron 51, Altman completed two deployments to the Western Pacific and Indian Ocean. In August 1987, he was selected for the Naval Postgraduate School-Test Pilot School Coop program and graduated with Test Pilot School Class 97 in June 1990 as a Distinguished Graduate. After graduation, he spent the next two years as a test pilot working on various F-14 projects such as the air to ground separation effort, and aft center of gravity flying qualities evaluation, as well as the Navy evaluation of the Air Force F-15 S/MTD technology demonstrator. Selected to help take the new F-14D on its first operational deployment, his next assignment was to VF-31 at NAS Miramar where he served as Maintenance Officer and later Operations Officer. Altman was awarded the Navy Air Medal for his role as a strike leader flying over Southern Iraq in support of Operation SOUTHERN WATCH. Shortly following his return from this six month deployment, he was selected for the astronaut program. He has logged over 3400 flight hours in more than 40 types of aircraft.

NASA EXPERIENCE - Selected as an astronaut candidate by NASA in December 1994, Altman reported to the Johnson Space Center in March 1995. He has completed a year of training and was initially assigned to work technical aspects of orbiter landing and roll out issues for the Astronaut Office Vehicle Systems Branch.

RICHARD M. LINNEHAN (DVM)
STS-90 Payload Commander & Mission Specialist-1

PERSONAL DATA - Born September 19, 1957, in Lowell, Massachusetts. Single. He enjoys mountain biking, swimming, skiing, hiking, and natural history. His mother, Carol J. Robinson, resides in Jensen Beach, Florida. His father, Richard H. Linnehan, is deceased.

EDUCATION - Graduated from Pelham High School, Pelham, New Hampshire, in 1975; received a bachelor of science degree in animal sciences with a minor in microbiology from the University of New Hampshire in 1980; the degree of Doctor of Veterinary Medicine from the Ohio State University College of Veterinary Medicine in 1985.

ORGANIZATIONS - Member of the American Veterinary Medical Association, the American Association of Zoo Veterinarians, and the International Association of Aquatic Animal Medicine.

SPECIAL HONORS - Navy Group Achievement Award, Navy Commendation Medal.

EXPERIENCE - After graduating from the Ohio State University College of Veterinary Medicine in June 1985, Dr. Linnehan entered private practice in small animal/exotic veterinary medicine and was later accepted to a 2-year (1986-1988) joint internship in zoo animal medicine and comparative pathology at the Baltimore Zoo and the Johns Hopkins University. After completing his internship Dr. Linnehan was commissioned as a captain in the U.S. Army Veterinary Corps and reported for duty in early 1989 at Naval Ocean Systems Center, San Diego, California, as chief clinical veterinarian for the U.S. Navy's Marine Mammal Project. During his assignment at Naval Ocean Systems Center Dr. Linnehan initiated and supervised research in the areas of cetacean and pinniped anesthesia, orthopedics, drug pharmacokinetics and reproduction in direct support of Naval mobile marine mammal systems stationed in California, Florida, and Hawaii.

NASA EXPERIENCE - Selected by NASA in March 1992, Dr. Linnehan reported to the Johnson Space Center in August 1992. He completed one year of training and is qualified for future flight assignments as a mission specialist. Dr. Linnehan was initially assigned to flight software verification in the Shuttle Avionics Integration Laboratory (SAIL). He was subsequently assigned to the Astronaut Office Mission Development Branch, working on payload development, and mission development flight support for future Space Shuttle missions. In 1996, Dr. Linnehan flew on STS-78 the Life Sciences and Microgravity Spacelab (LMS) mission. STS-78 launched June 20, 1996 and landed July 7, 1996 becoming the longest Space Shuttle mission to date. This mission served as a model for future studies onboard the International Space Station. The LMS mission included studies sponsored by ten nations and five space agencies. The international crew included 5 Americans a Frenchman, a Canadian, a Spaniard, and an Italian.

Linnehan has logged over 405 hours in space.

KATHRYN P. (Kay) HIRE (Commander, U.S. Naval Reserve)
STS-90 Mission Specialist-2

PERSONAL DATA - Born August 26, 1959, in Mobile, Alabama. She enjoys competitive sailing, snow skiing, scuba diving, and fishing.

EDUCATION - Graduated from Murphy High School, Mobile, Alabama, in 1977. Bachelor of science degree in engineering and management from the U.S. Naval Academy, 1981. Master of science degree in space technology from Florida Institute of Technology, 1991.

ORGANIZATIONS - Association of Naval Aviation, American Institute of Aeronautics and Astronautics, Institute of Navigation, Society of Women Engineers, U.S. Sailing Association.

SPECIAL HONORS - National Defense Service Medal, Coast Guard Special Operations Service Ribbon, Navy and Marine Corps Overseas Service ribbon, Space Coast Society of Women Engineers Distinguished New Woman Engineer for 1993.

EXPERIENCE - After earning her Naval Flight Officer Wings in October 1982, Hire conducted worldwide airborne oceanographic research missions with Oceanographic Development Squadron Eight (VXN-8) based at NAS Patuxent River, Maryland. She worked as Oceanographic Project Coordinator, Mission Commander and Detachment Officer-in-Charge on board the specially configured P-3 aircraft.

Hire instructed student naval flight officers in the classroom, simulator, and on board the T-43 aircraft at the Naval Air Training Unit on Mather Air Force Base, California. She progressed from Navigation Instructor through Course Manager to Curriculum Manager and was awarded the Air Force Master of Flying Instruction.

In January 1989, Hire joined the Naval Air Reserve at NAS Jacksonville, Florida. Her tours of duty included Squadron Augment Unit VP-0545 and Anti-submarine Warfare Operations Center 0574 and 0374.

Hire became the first female in the United States assigned to a combat aircrew when she reported to Patrol Squadron Sixty-Two (VP-62) on May 13, 1993. As a Patrol Plane Navigator/Communicator she deployed to Iceland, Puerto Rico and Panama. Hire later served at NAS Joint Reserve Base New Orleans with CV-63 USS Kittyhawk 0482 and Tactical Support Center 0682. Presently she is a member of the Naval Reserve, Commander Seventh Fleet Detachment 111 at Naval Air Station Dallas, Texas.

Hire began work at the Kennedy Space Center in May 1989, first as an Orbiter Processing Facility 3 Activation Engineer with EG&G and later as a Space Shuttle Orbiter Mechanical Systems Engineer for Lockheed Space Operations Company. In 1991 she certified as a Space Shuttle Test Project Engineer (TPE). From the TPE computer console position in the Launch Control Center, she integrated all technical aspects of Space Shuttle turnaround maintenance from landing through next launch. Additionally, she headed the checkout of the Extravehicular Mobility Units (spacesuits) and Russian Orbiter Docking System. Hire was assigned Supervisor of Space Shuttle Orbiter Mechanisms and Launch Pad Swing Arms in 1994.

NASA EXPERIENCE - Selected by NASA in December 1994, Hire reported to the Johnson Space Center in March 1995, and completed a year of training and evaluation. She has worked in mission control as a spacecraft communicator (CAPCOM) since April 1996.

DAFYDD (Dave) RHYS WILLIAMS (M.D.)
STS-90 Mission Specialist-3

PERSONAL DATA - Born May 16, 1954, in Saskatoon, Saskatchewan. Married to the former Cathy Fraser of Pointe-Claire, Quebec. They have a son and a daughter. Dr. Williams enjoys flying, scuba diving, hiking, sailing, kayaking, canoeing, downhill and cross-country skiing. His mother, Isobel Williams (nee Berger), resides in Williamsburg, Ontario. His father, William Williams, is deceased. Her father, Arthur Fraser, resides in Sechelt, British Columbia. Her mother, Olga Fraser (nee Bardahl), is deceased.

EDUCATION - Attended High School in Beaconsfield, Quebec. Bachelor of science degree in biology from McGill University, Montreal, 1976.; Master of science degree in physiology, Doctorate of medicine, and Master of Surgery from McGill University, Montreal, in 1983. Completed residency in Family Practice in the Faculty of Medicine, University of Ottawa in 1985. Obtained Fellowship in Emergency Medicine from the Royal College of Physicians and Surgeons of Canada, following completion of a Residency in Emergency Medicine at the University of Toronto, 1988.

ORGANIZATIONS - Member, College of Physicians and Surgeons of Ontario, the Ontario Medical Association, the College of Family Physicians of Canada, the Royal College of Physicians and Surgeons of Canada, the Canadian Association of Emergency Physicians, the Aerospace Medical Association, the Canadian Society for Aerospace Medicine and the
Canadian Aeronautics and Space Institute. Past affiliations include: the Society for Neuroscience, the New York Academy of Science and the Montreal Physiological Society.

SPECIAL HONORS - Awarded the Commonwealth Certificate of Thanks (1973) and the Commonwealth Recognition Award (1975) for his contribution to the Royal Life Saving Society of Canada. Academic awards include the A.S. Hill Bursary, McGill University, in 1980; the Walter Hoare Bursary, McGill University, in 1981; the J.W. McConnell Award, McGill University, 1981-1983. He was named Faculty Scholar, in 1982, and University Scholar, in 1983, by the Faculty of Medicine, McGill University. In 1983, he also received the Psychiatry Prize and the Wood Gold Medal from the Faculty of Medicine and was named on the Dean's Honor List by the Physiology Department, McGill University, for
his postgraduate research. He was twice awarded the second prize for his participation in the University of Toronto Emergency Medicine Research Papers Program, in 1986 and 1988, and received top honors in that competition in 1987.

EXPERIENCE - Dr. Williams received postgraduate training in advanced invertebrate physiology at the Friday Harbour Laboratories, University of Washington, Seattle, Washington. Subsequently, his interests switched to vertebrate neurophysiology
when, for his Master's Thesis, he became involved in basic science research on the role of adrenal steroid hormones in modifying the activity of regions within the central nervous system involved in the regulation of sleep wake cycles. While working in the Neurophysiological Laboratories at the Allan Memorial Institute for Psychiatry, he assisted in clinical studies of slow wave potentials within the central nervous system.

His clinical research in Emergency Medicine has included studies evaluating the initial training and skill retention of cardiopulmonary resuscitation skills, patient survival from out-of-hospital cardiac arrest, the early identification of trauma patients at high risk and the efficacy of tetanus immunization in the elderly.

In 1988, he became an Emergency Physician with the Department of Emergency Services at Sunnybrook Health Science Centre as well as a Lecturer with the Department of Surgery, University of Toronto. He served as a member of the Air Ambulance Utilization Committee with the Ministry of Health in Ontario, both as an academic Emergency Physician and later as a representative of community Emergency Physicians. In addition, he has trained basic ambulance attendants, paramedics, nurses, residents and practicing physicians in cardiac and trauma resuscitation as a Course Director in Advanced Cardiac Life Support with the Canadian Heart and Stroke Foundation and in Advanced Trauma Life Support with the American College of Surgeons.

From 1989 to 1990, he served as an Emergency Physician with the Emergency Associates of Kitchener Waterloo and as Medical Director of the Westmount Urgent Care Clinic. In 1990, he returned to Sunnybrook as Medical Director of the ACLS Program and Coordinator of Postgraduate Training in Emergency Medicine. Subsequently, he became the Acting Director of the Department of Emergency Services at Sunnybrook Health Science Centre, Assistant Professor of Surgery, University of Toronto and Assistant Professor of Medicine, University of Toronto.

Dr. Williams was selected by the Canadian Space Agency in June 1992. He completed basic training and in May 1993 was appointed Manager of the Missions and Space Medicine Group within the Astronaut Program. His collateral duty assignments have included supervising the implementation of Operational Space Medicine activities within the Astronaut Program, and the coordination of the Canadian Astronaut Program Space Unit Life Simulation (CAPSULS) Project. In February 1994 he participated in a 7-day space mission simulation. During this CAPSULS Project, he was the principal investigator of a study to evaluate the initial training and retention of resuscitation skills by non-medical astronauts. He was also assigned as one of the crew members and acted as the crew medical officer.

He remains active in life science and space medicine research, both as a Principal Investigator and as a Co-investigator. He has recently been appointed as an Assistant Professor of Surgery, McGill University, and is participating in clinical activities at St. Mary's Hospital and at the Montreal General Hospital.

NASA EXPERIENCE - In January 1995, Dr. Williams was selected to join the 1995 international class of NASA mission specialist astronaut candidates. He reported to the Johnson Space Center in March 1995 and completed training and evaluation in May 1996. On completing basic training, he was assigned to work technical issues for the Payloads/Habitability Branch of the Astronaut Office.

JAY CLARK BUCKEY, JR. (M.D.)
STS-90 Payload Specialist-1

PERSONAL DATA - Born June 6, 1956 in New York, New York. His parents, Jay Sr. and Jean Buckey, reside in Ft. Myers, Florida. Married to the former Sarah Woodroffe Masters of Summit, New Jersey daughter of Parke and Margaret Masters. They have one son and two daughters. Recreational interests include camping, history.

EDUCATION - Graduated from W. Tresper Clarke High School in Westbury, New York, in 1973. Earned a bachelor of science degree in electrical engineering from Cornell University in 1977, and a doctorate in medicine from Cornell University Medical College in 1981. Interned at New York Hospital-Cornell Medical Center, and completed residency at Dartmouth-Hitchcock Medical Center. NASA Space Biology Fellow at University of Texas (UT) Southwestern Medical Center.

ORGANIZATIONS - American Society for Gravitational and Space Biology (Executive Board Member 1991-1994), Aerospace Medicine Association, and American College of Physicians.

SPECIAL HONORS - Meritorious service award from the University of Texas for work on Spacelab Life Sciences-1 (SLS-1) (1991), Outstanding Teacher Award from the Class of 1994 at UT-Southwestern, Distinguished Graduate USAF School of Aerospace Medicine Primary Course (1987), two NASA Certificates of Recognition for hardware developed for SLS-1, NASA Biology Fellowship (1982), Thora Halstead Young Investigator Award, 1994.

PUBLICATIONS - Dr. Buckey has over 20 publications in the areas of space physiology, cardiovascular regulation and echocardiographic techniques.

EXPERIENCE - Medical internship, New York Hospital-Cornell Medical Center, New York, 1981-1982; NASA Space Biology Fellow, UT-Southwestern, 1982-1984; Research Instructor, Department of Medicine, UT-Southwestern, 1984-1986; Assistant Professor Medicine, UT-Southwestern, 1986-1994; Associate Professor Medicine, UT-Southwestern, 1995; Medicine Resident, Dartmouth-Hitchcock Medical Center, 1995-1996. Associate Professor of Medicine, Dartmouth Medical School, 1996-present; Flight Surgeon, U.S. Air Force Reserve, 457th Tactical Fighter Squadron at Naval Air Station Joint Reserve Base, Fort Worth, TX, 1987-1995. Dr. Buckey is on leave from Dartmouth Medical School to train as a Payload Specialist for the Neurolab mission, STS-90.

NASA EXPERIENCE - Co-investigator and project manager for the space flight experiment "Cardiovascular Adaptation to Zero-Gravity;" Spacelab Life Sciences-1; Alternate Payload Specialist, Spacelab Life Sciences-2.

James A. (Jim) Pawelczyk (Ph.D.)
STS-90 Payload Specialist-2

PERSONAL DATA - Born September 20, 1960, in Buffalo, New York. He identifies Elma, New York as his hometown, where his parents, Joseph and Rita Pawelczyk, continue to reside. Married to the Ruth A. Pawelczyk, M.D. (nee Anderson), daughter of Paul and Barbara Anderson, of State College, Pennsylvania. They have two children. Hobbies include cycling, swimming, woodworking, philately, and outdoor activities.

EDUCATION - Graduated from Iroquois Central High School, Elma, New York, in 1978; Earned two bachelor of arts degrees in biology and psychology from the University of Rochester, New York in 1982; a master of science degree in physiology from the Pennsylvania State University in 1985; and a doctor of philosophy degree in biology (physiology) from the University of North Texas in 1989. He completed a post-doctoral fellowship at the University of Texas Southwestern Medical Center in 1992.

PROFESSIONAL SOCIETIES - American Heart Association, American Physiological Society, American College of Sports Medicine, Society for Neuroscience.

HONORS AND AWARDS - Research Scientist, United States Olympic Swimming Trials, 1984; Pre-doctoral training award, National Institues of Health, 1988-1989; Research award, Texas Chapter of the American College of Sports Medicine, 1988; Post-doctoral training award, National Institues of Health, 1989-1992; Young Investigator Award, Life Sciences Project Division, NASA Office of Life and Microgravity Science Applications, 1994.

SCHOLARLY ACTIVITY - Dr. Pawelczyk is co-editor of Blood Loss and Shock, published in 1994. He has been a principal investigator or co-investigator on 11 federal and state grants and contracts, and has over 20 refereed journal articles and 3 invited book chapters in the areas of cardiovascular regulation and cardiovascular physiology.

EXPERIENCE - Post-doctoral fellowship in cardiovascular neurophysiology, University of Texas Southwestern Medical Center, 1989-1992; Visiting scientist, Department of Anaesthesia, Rigshospitalet, Copenhagen, Denmark, 1990; Assistant Professor of Medicine (Cardiology), University of Texas Southwestern Medical Center, 1992-1995; Director, Autonomic and Exercise Physiology Laboratories, Institute for Exercise and Environmental Medicine, Presbyterian Hospital of Dallas, 1992-1995; Assistant Professor of Bioengineering, University of Texas Southwestern Medical Center, 1995; Assistant Professor of Physiology and Kinesiology, Penn State University, University Park, Pennsylvania, 1995-present. Dr. Pawelczyk is on leave from Penn State University to train as a payload specialist for STS-90 (Neurolab).

NASA EXPERIENCE - User design group, GASMAP (Gas Analysis System for Metabolic Analysis Physiology); Unit principal investigator for the NASA Specialized Center for Outreach, Research and Training (NSCORT) grant in integrative physiology. He received a NASA Young Investigator Award in 1994 for his work in the area of autonomic neurophysiology. Dr. Pawelczyk is a co-investigator for experiments to be flown on the Neurolab mission, and two Shuttle-Mir (Phase 1B) flights.